Wyckoff Containment Remedy Evaluation

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A meeting at the Floyd|Snider office in downtown Seattle was held July 22, 2010 to discuss Ecology's Wyckoff Generational Remedy Evaluation draft document dated June 18, 2010 (GR). The meeting was attended by staff from Floyd|Snider, Aspect, Ecology, CH2M HILL, and EPA. The first part of the meeting was devoted to Ecology's presentation of concerns with the EPA Containment Remedy (CR). Ecology's concerns were presented in a meeting handout and are listed below in bullet format in Section 1 with some minor editing and reformatting for clarity.

Ecology's concerns focus on the possibility of DNAPL and/or dissolved contaminants leaking through the sheetpile wall and the Aquitard. However, their concerns do not connect the *possibility* of a leak to the concrete *probability* of a completed contaminant pathway at adverse concentrations to a human or aquatic receptor. The concerns also do not acknowledge EPA's ongoing commitment and accepted responsibility to respond if the CR is demonstrated to have failed and human and aquatic receptors are likely to be endangered.

Rather than responding directly, and in some cases redundantly, to each of Ecology's concerns with the CR, this Technical Memorandum approaches the protectiveness of the CR in terms of contaminant pathways to a receptor. For brevity and non-technical reader clarity, supporting documentation (text, tables, and figures) are not included in this Technical Memorandum, but are contained in the following general references: Engineering Evaluation of Groundwater and Soil Remediation Scenarios, 2005; Groundwater Conceptual Site Model Update Report, 2007; Soil Boring and Monitoring Well Construction Summary Technical Memorandum, 2009; Groundwater Quality Sampling Results Technical Memoranda (periodic since 1994); and Evaluation of Wyckoff Groundwater Level Data Technical Memoranda (periodic since 2004).

The protectiveness discussion is presented below in Section 2.

Ecology's earthquake and climate change concerns will not be addressed in this Technical Memorandum because these general, regional, and un-quantified factors are not usually included in Superfund Remedial Action Objectives or addressed in Remedial Alternatives.

Overall Conclusions: No new evidence was presented in the GR document or during the discussions that has not been used by EPA during the development, evaluation, and ongoing monitoring of the CR (with the exception of the speculative, but likely

inconsequential aquitard fault given the site geology and groundwater flow system). Moreover, the Ecology concerns do not alter EPA's belief that the CR is and will remain protective of real world human receptors and environmental receptors in Puget Sound water and sediment because the three primary contaminant pathways to potential receptors at the site are incomplete by CR design and natural attenuation.

Ongoing performance monitoring will also help ensure protectiveness and alert future operators of a problem. If the CR is demonstrated to have failed and human and aquatic receptors could be impacted, EPA and Ecology can respond at that future time.

Based on technical evaluation and professional judgment, the generally known risks of the CR are much less than the unintended consequences and unquantifiable unknown risks associated with implementation of any of the active and invasive GR Alternatives. Even the GR states that the CR "…is generally expected to be easily implemented with low risk" and that "The complexity and risk of implementing a generational remedy is considered moderate." Note: many known potential risks are NOT identified or discussed in the GR document. Some of the many additional risks and uncertainties that will drive capital (if not O&M) costs up are identified in the accompanying EPA evaluation of the GR document. Accounting for all the additional factors identified in the EPA evaluation, the complexity and risks to the community and environment of implementing the GR alternatives likely would be high.

1.0 Ecology concerns with Containment Remedy

Aquitard competency

- SE/SW aquitard missing
- Existence of more permeable lens within the aquitard that reduce the effectiveness of the aquitard
- Potential "hole" in the center of the site
- Cool inflow during thermal pilot
- Past fault rupture of aquitard

Hydraulic connectivity between upper and lower aquifers

- Well pair hydrographs show similar tidal cycle responses indicating hydraulic connectivity (especially VG-2L/VG-2U)

NAPL in lower aquifer

- Dissolved contaminants in lower aquifer
- DNAPL in more permeable lens within the aquitard
- DNAPL in lower aquifer in VG-2L
- Evidence of significant downward migration over the past 50 to 100 years
- Extraction system does not affect downward migration of DNAPL or lower aquifer flow
- Pathway exists from lower aquifer to surface water and sediments
- Expect contaminant concentrations to increase in the lower aquifer over time

Earthquake and climate change concerns

- Likelihood of additional aquitard ruptures
- Damage to containment remedy components
- Potential bulk sloughing and mass release
- Sea level increase and erosion effects

Other concerns

- Difficulty in monitoring the upper aquifer to determine compliance given existing contamination outside the sheetpile wall
- Reliance on longer-term net inward gradient ignores contaminants leaking through wall or aquitard that can't be pulled back during the daily tidal cycle
- Long-term competency of the sheetpile wall
- Sheetpile wall embedment in the aquitard especially in SE corner of site
- Potential for gradual or more severe release over time
- Remedy risks have significant consequences – unique site located in Puget Sound, aquatic resources, tribal fishing

2.0 Containment Remedy Protectiveness

As discussed in the introduction to this Technical Memorandum, Ecology's concerns focus on the possibility of DNAPL and/or dissolved contaminants migrating through the sheetpile wall and the Aquitard. Their concerns do not connect the *possibility* of a leak to a concrete *probability* of a completed pathway at adverse concentrations to a human or aquatic receptor.

Section 2.1 presents the general elements of the Site Conceptual Model (SCM) that contribute to the overall protectiveness of the CR and Section 2.2 presents the qualitative evaluation of the potential contaminant pathways from the site to receptors.

2.1 Site Conditions Contributing to CR Protectiveness

The following bullet items summarize the general site conditions and SCM elements that additively contribute to the overall protectiveness of the CR.

- Since 2004 vertical gradient well pairs (currently 10) installed in the Upper and Lower Aquifers have been monitored with dataloggers recording water levels at 15 to 30 minute intervals. Hydraulic containment has been maintained except for the 2009-2010 shakedown period when the power went down for many weeks, the extraction and treatment system was not run 24/7, and exceptional rainfall events occurred.
- There is no compelling evidence that DNAPL is continuing to migrate downward under the influence of gravity at the site. Most of the mobile Upper Aquifer DNAPL is immobilized or greatly retarded for four primary reasons:

    1) Most of the mobile DNAPL is trapped above the Aquitard in and on the numerous lower permeability layers within the Upper Aquifer.

2) Because the Upper Aquifer is brackish/saline, the density difference between the DNAPL and Upper Aquifer groundwater that drives downward migration is very slight typically ranging from 0.05 to 0.06 g/cm^3. The high salinity of the Lower Aquifer, which is greater than 10,000 ppm (and thus regulatorily defined as non-potable) beneath the northern third of the site will also inhibit further downward migration of DNAPL through the Lower Aquifer.

   The density difference driver is continuing to decrease as the Upper Aquifer DNAPL weathers and lighter fractions are eliminated.

3) Any mobile DNAPL that is still capable of downwardly migrating will reach residual saturation and not move further in the Upper Aquifer or Lower Aquifer at the site.

4) The CR maintains a net vertical groundwater flow up through the Aquitard that also retards downward DNAPL migration by generating an uplift force countering part of the DNAPL's downward force. Moreover the groundwater that passes up through the Aquitard and over the DNAPL will help dissolve the lighter fractions of the DNAPL making it more immobile.

- Although many borings and push/sonic probes have been installed to the top of the Aquitard and others through the Aquitard, no evidence of fully penetrating holes in the Aquitard have been identified. However, a few more permeable lenses within the Aquitard have been identified and may represent a partial pathway to the Lower Aquifer.

- The dissolved contaminant pathway (especially through the Lower Aquifer to surface water and sediment) is incomplete at the site because of the long distance and long time to reach the mudline and thus potentially impact receptors. The long time and distance allows degradation and sorption to occur. These factors are also assumed in the GR to mitigate the significant volumes of DNAPL and dissolved contaminants left in the environment inside and outside the sheetpile wall after completion of any of the proposed GR alternatives.

- There is a large volume of mobile DNAPL capped in the East Eagle Harbor OU-1 (including West Beach) adjacent to the site. Many years of ongoing monitoring has shown that surface water and sediments have not been adversely impacted to cause a failure of the remedy. However, the Lower Aquifer dewatering required in GR Alternative 2 has not been adequately (if at all) evaluated as to duration, quantity, quality, discharge requirements, treatment requirements, impacts on dissolved and DNAPL immediately outside the sheetpile wall and impacts on the already remediated Eagle Harbor OU's dissolved contaminants and DNAPL, and how to monitor the huge volume of the Upper and Lower Aquifers and Aquitard outside the sheetpile wall to assume no harm is done.

- Ongoing water quality monitoring has demonstrated that some dissolved contaminants have migrated to the Lower Aquifer at concentrations above the MCL, however because either the groundwater at the exceedance wells is non-potable (TDS >10,000 ppm) or is flowing in the direction of the non-potable portion of the Lower Aquifer, the MCLs are not likely to be applicable. Ongoing water quality monitoring has also not shown a

significant increase or decrease in contaminate concentrations indicating a likely steady state condition. Given the long flow paths, the contaminant concentration attenuation mechanisms, and the higher density non-potable groundwater the impacts to receptors are likely to be minimal.

- Although the Aquitard does not exist in the southeast corner of the site and thus the sheetpile wall is "hanging", ongoing water quality monitoring of the Upper and Lower Aquifer in the southeast corner (MW-21, PZ-3, and SE-02) shows there is little or no dissolved contaminant (or DNAPL) migrating to the Lower Aquifer. [Note: the USACE sheetpile wall as-built report coupled with 2008 boring logs of the new monitoring and vertical gradient wells show that the sheetpile wall was correctly keyed into the Aquitard everywhere except the SE corner of the site.] A large body of antidotal evidence also has been collected by numerous observers walking the east beach during low tide since the sheetpile wall was constructed in 2000/2001 that shows the number of east beach DNAPL seeps and sheen-spots have decreased significantly (most recently only 1 seep was observed). These observations indicate that the sheetpile wall is effective in cutting off the eastward migration of DNAPL from the site into Puget Sound.

- Biotic and abiotic degradation of the most mobile fractions is especially strong for naphthalene and benzene which have been identified as dissolved groundwater contaminants-of-concern at the site. After removal of the lighter and more soluble constituents, the remaining fraction of the DNAPL is heavy and thus relatively physically and chemically immobile.

- The only well drilled into the Lower Aquifer to find any potentially mobile DNAPL was VG-2L located in the northeast corner of the site. Ongoing groundwater monitoring of this well (screened only 2 feet below the few inch thick DNAPL seam with the sand pack extending to the DNAPL seam) shows exceedances of dissolved DNAPL constituents, however, not even close to the 10% of solubility industry rule-of-thumb for suspecting DNAPL nearby. The data demonstrate that the DNAPL detected at this location in the Lower Aquifer is not a major source of contamination.

- The extraction system historically has captured about 300 gallons of DNAPL per month. Assuming this steady rate is maintained, the extraction system will remove 960,000 gallons of DNAPL in 270 years consistent with the GR's time frame. Although one can argue with the steady rate assumption, the fact remains that the CR will likely remove a large percentage of the mobile DNAPL over time.

- The full CR as presented in the 2005 Engineering Evaluation has not been implemented. When the CR is constructed it is planned that it would consist of the following components that will minimize treatment plant O&M, enhance the effectiveness of the extraction system, and protect the existing sheetpile wall:

    - Site Cap. The cap would significantly reduce the amount of precipitation recharge entering the site that needs to be treated and to prevent direct contact with contaminated soil. The current extraction system total pumping rate is about 60 gpm. After the cap the pumping rate to maintain hydraulic containment is estimated to be about 10 gpm thus greatly reducing overall extraction and treatment costs.

- Shoreline Stabilization System. This system would protect the existing sheet pile wall that is exposed above the mudline and would mitigate lateral contaminant movement from the site. An impermeable and inert (FRP) sheetpile wall would likely be installed adjacent to the existing sheet pile wall and concrete would be placed between the two sheet pile walls to inhibit the long-term future corrosion and leakage through the sheet pile wall. (Requirements for the shoreline stabilization system would be evaluated as part of the engineering design.)
- Optimized Upper-Aquifer Groundwater Extraction Well System. Planning level estimates for the optimized extraction system include the installation of up to 15 new extraction wells spread evenly throughout the site thus enhancing the ability to maintain hydraulic containment. Not all wells would operate all the time, pumping would concentrate on the areas of the site needing the most water level control.
- Enhanced Containment System Effectiveness Monitoring. Twenty-three Lower Aquifer wells are currently in the ongoing water quality monitoring system. Ten Upper/Lower Aquifer well pairs comprise the Vertical Gradient monitoring system at the site. The well pairs are distributed to obtain representative coverage throughout the site. To monitor leakage through or under the sheetpile wall, a shoreline protection monitoring system would also be designed as an integral part of the shoreline system to monitor leaks through and under the sheetpile wall.
- The original CR concept was to include an upgradient cutoff wall to intercept groundwater underflow from the south from entering the site and thus requiring additional treatment plant capacity. However, after the installation of the south hillside piezometers (total of 9) it became obvious that there was no groundwater underflow coming from the south. The Aquitard was exposed at or very near the land surface and a likely manmade gash had cut through the Aquitard.

2.2 Slow leakage of DNAPL and dissolved contaminants

Slow leakage of DNAPL and dissolved contaminants beyond the physical containment "boundary" can occur via the following three pathways

- Through sheetpile wall above mudline direct to surface water (also includes LNAPL)
- Through the sheetpile wall to the Upper Aquifer to surface water/surface sediments
- Down through the Aquitard to the Lower Aquifer back up through the Aquitard to the Upper Aquifer to surface water/surface sediments

These three pathways are discussed in more detail below.

2.2.1 Leakage through the sheetpile wall above the mudline direct to surface water

A large body of antidotal evidence has been collected by numerous observers walking the beach during low tide since the sheetpile wall was constructed in 2000/2001. All the evidence shows that there is no leakage of NAPL or Upper Aquifer groundwater through the sheetpile wall above the mudline. Moreover, the sheetpile wall above mudline will be backed by a non-corrodible impermeable wall as a component of the CR Shoreline Protection structure (as described in Section 2.1).

The zone above the mudline within the Shoreline Protection will be monitored. Although there is DNAPL and dissolved contamination outside the sheetpile wall, the monitoring system will be designed to establish a baseline and excursions used to evaluate effectiveness of the sheetpile wall system and if a failure is demonstrated, additional actions can be taken by EPA. Note: Dealing with background contamination is not new and has been effectively dealt with at many other sites for many years throughout the Country.

This pathway is incomplete by CR design. Ongoing and future performance monitoring will help ensure protectiveness and alert future operators if a problem occurs. If the CR is demonstrated to have failed and human and aquatic receptors are likely to be endangered EPA and Ecology can respond at that future time.

2.2.2 Leakage through or under sheetpile wall to upper aquifer to surface water/surface sediments

The same monitoring system described above will also serve the monitoring needs of the groundwater pathway through or under the sheetpile wall to the Upper Aquifer to surface water/ surface sediments near the sheetpile wall.

The lack of groundwater and DNAPL impacts in the southeast corner of the site and east beach seeps have been discussed in Section 2.1 above.

This pathway is incomplete by CR design and natural attenuation. Ongoing and future performance monitoring will help ensure protectiveness and alert future operators if a problem occurs. If the CR is demonstrated to have failed and human and aquatic receptors are likely to be endangered EPA and Ecology can respond at that future time.

2.2.3 Leakage through Aquitard to Lower Aquifer to Aquitard to Upper Aquifer to surface water/surface sediments

The competency of the Aquitard and sheetpile wall has been discussed in Section 2.1 above. The bottom line is that the aquitard/sheetpile wall system may not be impermeable to DNAPL or dissolved contaminants, but no hole through the Aquitard has ever been identified. In addition, the current site water balance indicates that if leakage through the aquitard is occurring the total volume of water cannot be very large. The extraction system has been shown to be effective at maintaining hydraulic containment pumping 60 gpm that includes ALL precipitation recharge over the approximate 12 acre site. Estimates of leakage through the Aquitard are on the order of 10 gpm or less after the installation of the CR cap. This coupled with the site drilling results showing no holes in the Aquitard and site water balance show that the Aquitard can't be very leaky. This low flow rate up through the Aquitard is also supported by the fact that during the summer months the existing extraction system has to be throttled back to an extraction rate of approximately 25 gpm to prevent the pumps from cavitating. Cavitation in the existing pumps occurs at a static hydraulic lift of approximately 22 feet. Because hydraulic containment does not require a 20 foot drawdown throughout the Upper Aquifer, the required extraction rate for hydraulic containment with a cap (no direct precipitation recharge) would less than 25 gpm.

DNAPL and dissolved contaminants have been identified in the Lower Aquifer beneath the site. However, the results of the existing Lower Aquifer monitoring program of perimeter wells and interior "early warning" monitoring wells have not shown clear increasing trends even when the extraction system has not been operable and hydraulic containment has not been maintained (1st Quarter 2010 Water Level Technical Memorandum).

As discussed in Section 2.1, the groundwater flow path through the Lower Aquifer to receptors in surface water/sediment is very long and contaminants will be degraded by abiotic processes and possibly biotic processes in the transition zone between groundwater and surface water. These processes will occur and be effective even if all the adsorptive sites are overwhelmed over the long time frames envisioned in the GR. Moreover, reduction in contaminant concentrations by adsorption and the passive removal of DNAPL with the CR will also play a large role over the long term. Therefore, even within the GR time frame, if there are ongoing dissolved DNAPL components migrating to the Lower Aquifer they will not likely pose a threat to surface water or sediment. Also because of the very long flow paths any mobile DNAPL that does make it to the Lower Aquifer will reach residual saturation before posing a threat.

Moreover the groundwater that passes over the DNAPL will help dissolve the lighter fractions of the DNAPL making it less mobile.

This pathway is incomplete by CR design and natural attenuation. Ongoing performance monitoring will help ensure protectiveness and alert future operators if a problem occurs. If the CR is demonstrated to have failed and human and aquatic receptors are likely to be endangered EPA and Ecology can respond at that future time.

3.0 Conclusion

No new evidence was presented in the GR or during the discussions that has not been used by EPA during the development, evaluation, and ongoing monitoring of the CR (with the exception of the speculative, but likely inconsequential aquitard fault given the site geology and groundwater flow system). For this reason and the reasons stated above in Section 2, EPA believes that the CR is currently and will remain protective of real world human receptors and environmental receptors in Puget Sound water and sediment because the three pathways to potential receptors at the site are incomplete by CR design and natural attenuation. Ongoing performance monitoring will also help ensure protectiveness and alert future operators of a problem. If the CR is demonstrated to have failed and human and aquatic receptors could be impacted EPA and Ecology can respond at that future time.

Furthermore, based on technical evaluation and professional judgment, EPA believes that the generally known risks of the CR are much less than the unintended consequences and unquantifiable unknown risks associated with implementation of any of the three active and invasive GR Alternatives.